Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Advanced Television Systems and Their Impact Upon Existing Television Broadcast Service	)	MM Docket No. 87-268

COMMENTS OF MOTOROLA

MOTOROLA

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Motorola hereby submits these comments in response to the *Sixth Further Notice of Proposed Rule Making* in the above-captioned proceeding.[1] Motorola strongly supports the FCC's initiative to adopt digital television (DTV) assignment criteria that promote both the near term and long term recovery of underutilized broadcast television spectrum. To this end, Motorola recommends modifications to the FCC's proposed DTV allotment plan that 1) limits the number of allotments in UHF-TV channels 60-69 to no more than five compared to 30 in the FCC's plan and 2) maintains interference protection for land mobile stations now occupying portions of the 470-512 MHz band in certain cities. Motorola's proposals would expedite the spectrum recovery process and thus allow the FCC to address the urgent spectrum needs of the land mobile services, particularly those of public safety agencies, in a more meaningful and timely manner.

I. SUMMARY.

Motorola is a world-wide leader in the manufacturing of wireless communications devices such as cellular telephones, pagers, advanced messaging devices, and two-way radios for public safety and industrial applications. With annual revenues of approximately $30 billion dollars, Motorola's business interests demand that it maintain a keen focus on all spectrum management efforts.

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[1] *Sixth Further Notice of Proposed Rule Making,* MM Docket No. 87-268, released August 14, 1996 [hereinafter *Sixth Further Notice*].

The FCC is now developing a broadcast television allotment plan to facilitate the transition to digital television service within the U.S. This is perhaps the last opportunity to foster major improvements in the efficient use of non-government allocations below 1 GHz -- the so-called "beach front property" of the electromagnetic spectrum. Motorola encourages the Commission to seize this opportunity and take the necessary steps that benefit all American consumers.

The broadcast television service is allocated nearly 400 MHz of this valuable resource and, due to limitations with its existing technology, can only use about 120 MHz in any given market. Fortunately, advancements in digital television service will provide for greater spectrum efficiency which can allow the FCC to make portions of the broadcast allocation available for use by alternative services. In particular, the spectrum now allocated to UHF-TV channels 60-69, which is not ideal spectrum for broadcasting purposes, is viewed as a potential home for new land mobile services.

Motorola strongly supports that initiative and urges the FCC to adopt technical policies in this proceeding that allow for the early recovery of UHF channels 60-69. Motorola has analyzed the FCC's allotment plan and proposes specific modifications to reduce the number of DTV allotments in that band to no more than five without adding significant costs to the broadcast service. Motorola urges the FCC to consider Motorola's proposals and minimize the number of DTV assignments on channels 60-69.

In addition, Motorola has reviewed the FCC's allotment plan and found serious potential interference problems to land mobile stations now occupying certain UHF-TV channels from 14-20 in eleven major markets. In some cases, the FCC proposes DTV allotments as close as two miles to the reference coordinates of adjacent channel land mobile cities. Without significant reductions in out-of-band emissions (at least 30 dB) land mobile use of its allocated spectrum will be impossible. Again, Motorola provides specific recommendations for alternative assignments to minimize this inter-service interference problem.

II. MOTOROLA SUPPORTS THE FCC's EFFORTS TO IMPROVE THE OVERALL EFFICIENCY OF THE TELEVISION BROADCAST SPECTRUM ALLOCATIONS

In this phase of the long-standing DTV (previously HDTV) proceeding, the Commission is proposing an allotment plan that would implement its previously adopted policy of encouraging the digital television transition by temporarily providing each broadcaster with a second 6 MHz channel.[2] The intent is to allow broadcasters to simulcast the existing NTSC transmission format as well as any new advanced television format until sufficient numbers of consumers install advanced television receivers. Upon completion of the transition period when a "critical mass" of new receivers is in place, broadcasters would be required to return one of their two 6 MHz channels. In large part, the FCC's *Sixth Further Notice* provides a listing of the DTV channel allotments that would be available to existing broadcast stations and permittees during the transition period.

However, the *Sixth Further Notice* proposes more than a DTV allotment plan. In this document, the FCC attempts to eventually repack all broadcast television to a "core" allocation of TV channels 7 through 51.[3] Eventually, the FCC would recover the remaining portions of the existing broadcast allocation and make such spectrum available for alternative purposes. In so doing, the FCC emphasized that in reducing the amount of spectrum allocated to broadcast television, it would not be reducing the number of broadcasting outlets given the more efficient assignment possibilities associated with DTV.[4]

Motorola strongly supports the FCC's perspective and notes that this policy has the distinct opportunity to duplicate the tremendous benefits derived from the FCC's previous

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[2] *Second Report and Order/Further Notice of Proposed Rule Making,* MM Docket No. 87-268, 7 FCC Rcd 3340 (1992).

[3] *Sixth Further Notice* at ¶19.

[4] *Id.* at ¶16.

actions at 800 MHz.[5] With its actions in *Docket 18262* and subsequent proceedings, the FCC: 1) created the cellular radio service which ultimately led to the development of personal communications services, 2) provided spectrum for public safety agencies with interoperability provisions, 3) invented the SMR service which encouraged the development of trunked radio technology that doubled spectral efficiency and ultimately led to even more efficient enhanced SMR services, 4) provided spectrum for nationwide and regional paging, 5) spurred development of advanced two-way messaging technology utilized by narrowband PCS licensees, and 6) created air-to-ground telephone service. Reallocating UHF TV channels 70-83 to the land mobile services allowed for the development of an invigorated wireless communications industry that now generates tens of billions of dollars into the American economy each year while employing hundreds of thousands of people.[6][7]

Without questioning the public interest benefits of over-the-air broadcasting in an era of successful alternative delivery methods, Motorola believes that the FCC is justified in pursuing a recovery of a portion of the spectrum allocated for this purpose. As discussed by the FCC, and confirmed by Motorola's own analysis as detailed in these comments,

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[5] *In the Matter of An Inquiry Relative to the Future Use of the Frequency Band 806-890 MHz; and Amendment of Parts 2, 18, 21, 73, 74, 89, 91, and 93 of the Rules Relative to Operations in the Land Mobile Service Between 806 and 960 MHz,* Docket No. 18262, First Report and Order and Second Notice of Inquiry, 35 Fed Reg 8644 (1970) [hereinafter *Docket 18262*].

[6] *See e.g., Implementation of Section 6002(B) of the Omnibus Budget Reconciliation Act of 1993,* FCC 95-317, 10 FCC Rcd 8844 (1995). This FCC report cites, for example, annual service revenues for cellular telephone service at more than 14 billion dollars and a total user investment of 25 billion dollars in private land mobile infrastructure.

[7] In light of the tremendous success of this allocation, it is interesting to review the opposition of the broadcast industry as reflected in the record of those proceedings. For example, the broadcast industry vigorously warned that reallocation of broadcast spectrum would defeat FCC initiatives for improved land mobile spectrum efficiency and that land mobile equipment manufacturers "will drag their feet" in designing more efficient radio systems. *Memorandum Opinion and Order,* Docket No. 18261, RM-566, Docket No. 18262, released September 24, 1970 at 5. Of course, the 800 MHz allocation directly led to the deployment of trunked and cellular technologies which increased spectrum efficiency and led to the development of new wireless applications and, thus, increased user demand.

recovery of significant portions of the television spectrum can occur without reducing the number of broadcast outlets. Given the more robust nature of the DTV technologies as opposed to the existing NTSC service, the FCC will be able to utilize a higher percentage of the allocation in any given area.[8] Once the transition to digital TV is completed, all existing broadcast television stations will be able to co-exist within TV Channels 7-51 with capacity remaining for additional allotments. Thus, recovery of spectrum can proceed without compromising the effectiveness of over the air broadcasting service.

At the same time, the opportunity to repack the broadcast television spectrum with minimal costs comes at a time when land mobile services, primarily public safety services and business and industrial dispatch services, require additional spectrum. This shortage of land mobile capacity is not for lack of adopting more spectrum efficient operating techniques. In contrast to the broadcast service, the land mobile services have continually adopted measures to improve their utilization of their limited allocations. Nearly, every market segment of the land mobile industry has adopted more spectrum efficient technologies to address their own spectrum shortages largely ***without FCC mandates.*** For example, SMRs are voluntarily converting serviceable analog trunking equipment into digital systems offering a 3:1 improvement for radiotelephone service and as much as 6:1 improvement for dispatch service. Public safety users voluntarily defined a technology standard for digital radio that reduces communications channel widths from 25 kHz to 12.5 kHz and, eventually, 6.25 kHz. Other private land mobile users overwhelmingly supported the FCC's "refarming" initiative that will also reduce channel widths to 12.5 kHz and, subsequently, 6.25 kHz.[9] Paging carriers are deploying advanced digital modulation schemes to offer advanced two-way services and increase capacity. Despite these self-

[8] Currently, due to the limitations of NTSC technology and the resultant assignment "taboos" only 120 MHz of the allocated 402 MHz is available at any given location. *Sixth Further Notice* at fn 26.

[9] The industry now awaits Commission action on a few technical "clean-up" issues and service consolidation issues before fully implenting the refarming decisions.

imposed efforts at increasing spectrum efficiency, public safety and critical industries are still facing spectrum shortages because of increasing use and new radio based imaging applications.[10]

Recently, the Public Safety Wireless Advisory Committee ("PSWAC") completed a year long analysis of the communications needs for public safety agencies at the request of the FCC, NTIA and the U.S. Congress. In its report submitted to the FCC in Gen Docket No. 96-86, the PSWAC committee concluded that immediate additional spectrum allocations for public safety use are now needed to offset critical shortages.[11] In part, the PSWAC committee recommends that:[12]

> [I]n the short term, voice and data operations require approximately 25 MHz of new Public Safety allocations. By the year 2010, as much as an additional 70 MHz may be needed for these applications, including image and video requirements.

The PSWAC recommendations are consistent with those forecasted by the NTIA and the COPE Petition.

Although subsequent proceedings are needed to fully discuss the potential reallocation options for recovered broadcast television spectrum, Motorola believes that there is ample evidence of need for the FCC to continue on its endeavor to reclaim

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[10] The need for additional land mobile spectrum was recently confirmed by the National Telecommunications and Information Administration (NTIA) in 1994. In its report entitled *National Land Mobile Spectrum Requirements* (NTIA TM 94-160), the NTIA concluded that the private land mobile requires an estimated 104 MHz of additional spectrum for government and non-government use over the next ten years even after assuming that the FCC completes its Refarming proceedings in PR Docket No. 92-235. *National Land Mobile Spectrum Requirements* at p. 147. Also, on Dec. 23, 1993 the Coalition of Private Users of Emerging Technologies ("COPE") filed a petition for rulemaking indicating that public safety and industrial land mobile users require as much as 75 MHz of spectrum for advanced imaging and data transfer services.

[11] *The Development of Operational, Technical, and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communication Requirements Through the Year 2010*, WT Docket No. 96-86, 11 FCC Rcd 12460 (1996). *See also,* Public Safety Wireless Advisory Committee, Final Report, September 1996 [*hereinafter PSWAC Final Report*].

[12] *PSWAC Final Report* at p. 21.

underutilized broadcast spectrum. This opportunity presents a win-win situation for both the broadcasters and the land mobile services as it is apparent that new DTV service can be accommodated in less spectrum than now currently allocated for NTSC broadcast television. To allow this opportunity to pass without fostering more intensive utilization of the spectrum would deprive the American public of the benefits found in new services, would cost American jobs, and would perpetuate a situation where industries critical to this nation's industrial infrastructure, and public safety, are forced to squeeze unobtainable efficiencies from inadequate allocations.

III. THE FCC CAN FURTHER OPTIMIZE ITS DTV ALLOTMENT PLAN TO FACILITATE THE EARLY RECOVERY OF UHF-TV CHANNELS 60-69.

In proposing its DTV allotment plan, the FCC noted the benefits of ultimately containing all television broadcast service to a "core" allocation located between existing channels 7 and 51.[13] The Commission noted that attempting to provide each broadcaster with a DTV allotment in the core allocation would: 1) provide the vast majority of broadcasters the capability to provide DTV service on a channel that is technically most suited for DTV operation, 2) allow some 90 percent of existing broadcasters to provide DTV services on the same channel both during and after the transition, and 3) allow for a recovery of spectrum outside the core allocation without forcing many broadcasters to move twice.[14]

Motorola supports this attempt by the FCC and urges the Commission to limit DTV allotments to the core allocation to the maximum extent possible. More to the point, Motorola agrees with the FCC's conclusion that this approach may "facilitate the early

[13] *Sixth Further Notice* at ¶25.

[14] *Id.* at ¶¶24, 25.

recovery of a portion of this spectrum", namely, UHF-TV channels 60-69.[15] As the Commission explained, these channels contain only 97 of the existing 1600 television licenses currently authorized in the U.S. so new services could be introduced "almost immediately" while protecting the relatively few analog and digital broadcasters in this band.[16] To optimize this opportunity, the FCC's proposed allotment plan attempts to minimize any DTV allotments in UHF-TV channels 60-69.

This is one of Motorola's main interests in this proceeding. Motorola certainly concurs with the FCC's observation that "there are other uses" for the spectrum now used by TV channels 60-69. Indeed, this spectrum is ideal for land mobile applications. Its proximity to existing land mobile allocations at 806-824 would allow for the development of a single handset capable of operation across the entirety of the band thus enhancing interoperability opportunities. Also, while this is not the time to propose specific allocations for this spectrum, the FCC must keep in mind the report filed by the PSWAC committee indicating that a communications crisis looms if public safety agencies do not obtain significant new allocations. Motorola cannot identify any alternative spectrum that would provide the near term benefits that this spectrum offers.[17] Thus, it is important to exhaustively pursue this opportunity to determine if this spectrum can be recovered in the near term without significant costs imposed on the broadcast community.

Motorola agrees that the key is to limit now the number of DTV allotments in TV channels 60-69, ideally to zero, so that any preclusive effect of the broadcast stations occupying this spectrum is not increased.[18] The allotment plan contained in the *Sixth*

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[15] *Id.*

[16] *Id.*

[17] Recognizing this, the PSWAC Steering Committee recommends that the FCC's and NTIA's first priority action should to grant public safety users access to portions of the unused spectrum in the 746-806 MHz band within the next five years. *PSWAC Final Report* at 21.

[18] Even the 97 existing NTSC stations now licensed on UHF-TV channels 60-69 restrict the amount of spectrum available for immediate use by alternative service. See *infra*, p. 11.

Further Notice minimizes the number of DTV allotments in channels 60-69 to 30. It was Motorola's intent to review this analysis to determine whether this number of allotments can be reduced even further.

Motorola's research on the TV channel 60-69 DTV allotments is fully reported in Appendix A. Essentially, Motorola used the FCC's simulation program but placed a higher "penalty" for assigning DTV allotments to UHF-TV channels 60-69 and, as further described below, increased the priority to maintain the level of existing protection to land mobile stations operating on UHF-TV channels 14-20. In so doing, Motorola routinely found that alternative channels, principally in the core allocation, were available for allotment to existing licensees. Motorola's results indicate that the FCC's proposed plan can be significantly improved from the perspective of enhancing the opportunity for early recovery of TV channels 60-69.

Motorola performed several analyses utilizing the FCC's simulation code. The first focused solely on reassigning new channels to the FCC's DTV allotments in Channels 60-69 while attempting to maintain a constant "cost" factor imposed on broadcasters.[19] Focusing on limiting DTV assignments in UHF TV channels 60-69 and using the FCC assignment criteria, Motorola reduced the number of these allotments from 30 to 5 as shown below:

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[19] The FCC's simulated annealing method "employs a system of penalties that attach to conditions that fall short of specified objectives. The simulated annealing method seeks to minimize the sum of these penalties, or 'costs,' to achieve an optimum condition." These penalties include DTV-to-NTSC and NTSC-to-DTV cochannel and upper and lower adjacent channel interference penalties, DTV-to-DTV cochannel and upper and lower adjacent channel interference penalties, radio astronomy related adjacent channel penalties for channels 36 and 38, VCR related penalties for channels 3 and 4, FM radio related penalties for channel 6, land mobile channel interference penalties for the relevant channels in the relevant locations, and other penalties designed to promote allocations into the FCC's desired band of channels 7 through 51. *Sixth Further Notice* at ¶85.

Motorola Allotment Option 1

DTV ASSIGNMENTS REMAINING IN CHANNELS 60-69			
STATE	*CITY*	*NTSC CHANNEL*	*DTV CHANNEL*
CA	STOCKTON	64	69
NJ	CAMDEN	23	66
NJ	NEWTON	63	61
PA	ALLENTOWN	69	67
PA	PHILADELPHIA	17	64

In subsequent analyses, Motorola was able to reduce the number of DTV allotments in UHF TV Channels 60-69 to just two by allowing, under the terms of the computer program, some "short-spacing" between co-channel DTV allotments.[20] The results of this analysis are as follows:

Motorola Allotment Option 2

DTV ASSIGNMENTS REMAINING IN CHANNELS 60-69			
STATE	*CITY*	*NTSC CHANNEL*	*DTV CHANNEL*
CA	STOCKTON	64	69
NJ	NEWTON	63	61

These benefits have been gained by short-spacing the following set of DTV allotments.

[20] The FCC imposed a "hard limit" separating co-channel DTV allotments by 175 kilometers so that solutions at lesser separations were deemed invalid. However, in some instances, short-spacings may be appropriate solutions where terrain or other considerations minimize its impact. Motorola notes that in its review of the proposed allotment plan currently located on the National Association of Broadcasters's Internet webpage (http://www.nab.org) it has found some 16 different instances where DTV to DTV co-channel allotment are short-spaced *i.e.,* are less than the FCC's DTV cochannel separation distance of 175 kilometers. Motorola has not, however, exhaustively reviewed the NAB's plan and reserves full comment on this plan until the reply round.

List of Short-Spaced DTV Allotments[21]

1. Sacramento, CA and San Francisco, CA spaced 102 km.
2. Manchester, NH and Rutland, VT spaced 144 km.
3. New York, NY and Philadelphia, PA spaced 128 km.
4. Harrisburg, PA and Philadelphia, PA spaced 143 km.
5. Hartford, CT and Marlborough, MA spaced 128 km.
6. Hartford, VT and Marlborough, MA spaced 142 km.
7. San Bernardino, CA and Twenty-nine Palms CA spaced 138 km.
8. Baltimore, MD and Allentown, PA spaced 171 km.
9. New York, NY and Allentown, PA spaced 125 km.
10. Camden, NJ and Newark, NJ spaced 135 km.
11. Bakersfield, CA and Los Angeles, CA spaced 148 km.
12. Montclair, NJ and Vineland, NJ spaced 137 km.

The benefits of the Motorola's Allotment Option 1 were achieved with only a minor increase in the "cost" of the solution as calculated by the FCC's program. Motorola recognizes that the list of short-spaced DTV assignments detailed in Allotment Option 2 may not be fully viable solutions given the terrain and market areas surrounding each of those communities. Further case-by-case analysis should be performed to determine whether the proposed assignments materially affect the ability of the broadcast stations to offer DTV service to their community of license.[22] Motorola strongly encourages the FCC, however, to implement such a policy that eliminates "hard limits" in all cases and entertain *ad hoc* modifications to its DTV allotment plan that enhance the opportunity for early recovery of UHF-TV channels 60-69.

Finally, Motorola reminds the FCC that limiting DTV assignments in UHF-TV Channels 60-69 does not address the issue of the existing NTSC assignments in this band or their eventual relocation. Under the interference criteria adopted for TV/LM sharing in channels 14-20, which is overly protective for use at UHF-TV channels 60-69 due to the

[21] As described in Appendix A, this particular solution involved minimizing DTV allotments in channels 60-69 as well as limiting short-spaced DTV allotments to land mobile facilities in channels 14-20. Thus, this list of short-spaced DTV allotments was generated by attempting to optimize both conditions.

[22] Indeed, many of the difficulties in developing a DTV allotment plan may not prove relevant when actual deployment occurs given the probability that not all NTSC stations will choose to simulcast two broadcast stations.

differing propagation characteristics that exist at the polar ends of the UHF-TV band, the theoretical preclusive effect of these NTSC stations limits the immediate usefulness of the spectrum for new services. Motorola urges the FCC to consider methods of accelerating the transition of these NTSC stations to other portions of the band in as short a time as possible. Also, should the UHF-TV channels 60-69 become available for shared land mobile use in the near term, the FCC must modify the interference criteria from that used at UHF-TV channels 14-20 to account for the propagation penalties. This will allow land mobile service at lesser separations than otherwise predicted and reduce the preclusive effects of the NTSC assignments. Motorola stands ready to assist the FCC in these considerations.

IV. THE FCC MUST MAINTAIN INTERFERENCE PROTECTION TO LAND MOBILE STATIONS OPERATING ON UHF-TV CHANNELS 14-20 (470-512 MHz).

Concurrent with its actions in the mid-1970's to reallocate UHF-TV channels 70-83, the FCC also provided for the shared land mobile use of some UHF-TV channels within 14-20 in eleven major markets across the country.[23] Although the spectrum occupied at UHF-TV channels 60-69 provides the greatest opportunity for early recovery by the FCC, Motorola is also focused on the continued availability and reliability of existing land mobile sharing in this spectrum. Motorola views this as a critical issue[24] as a

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[23] *In the Matter of Amendment of Parts 2, 89, 91, and 93; geographic reallocation of UHF-TV Channels 14 through 20 to the land mobile radio services for use within the 25 largest urbanized areas of the United States,* Docket No. 18261, *First Report and Order,* 23 FCC 2d 325 (1970). *See also,* 47 C.F.R. §90.301 of the FCC's Rules.

[24] In this regard, the FCC seeks comments on whether UHF-TV channel 20, now allocated in Philadelphia to land mobile service, should remain a land mobile channel or whether the "reduction in broadcast service interference would outweigh the benefits of maintaining channel 20 for land mobile service in Philadelphia." *Sixth Further Notice* at ¶77. Motorola strongly opposes any suggestion of reallocating channel 20 in Philadelphia to the broadcast service unless a) a suitable spectrum alternative is made available and b) either the broadcast industry or the FCC provides full funding for the relocation of these licensees. According to Motorola's records, over 16,000 mobile units are operating over 9,600 base stations on channel 16 and eastern Pennsylvania is frequency deficient across all bands. Given the

high percentage of these land mobile operations, particularly in New York and Southern California, are utilized by public safety agencies.[25]

The FCC's *Sixth Further Notice* notes thirteen cases where the FCC's proposed allotment plan "short-spaces" co-channel and adjacent channel land mobile operations by less than 155 miles or 110 miles respectively.[26] Further, these proposed short-spacings are far from being *de minimis* violations of the spacing requirements -- some DTV allotments are a mere 2 miles from adjacent land mobile city center reference coordinates. These assignments, without any change, would cause severe interference to these LM services, as well as potentially causing LM interference to the associated DTV receivers. Without offering any suggestions, the FCC indicates that, with respect to adjacent channel interference, " we believe that there are engineering solutions available to handle any adjacent channel interference concerns between land mobile and DTV."[27]

Motorola has reviewed those assignments and offers DTV allotment alternatives that better protect land mobile and TV operations. In addition, Motorola provides significant analysis to adjacent channel interference concerns and offers suggested changes that could help minimize real world interference. The options include 1) requiring reduced DTV out-of-band emissions and 2) modifying the DTV allotment by modifying the DTV to DTV assignment policies (*i.e.,* allowing DTV to DTV "short-spacings" on an *ad hoc* basis). Attached at Appendix B is a more detailed technical discussion of Motorola's

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public interest benefits associated with private land mobile operations, it is inconceivable for the FCC or the broadcast industry to discuss evicting these users without alternative spectrum identified.

[25] In addition to the sharing allowed by Docket 18261, over the years, the FCC has allocated, on an *ad hoc* basis, some additional UHF-TV spectrum for the exclusive use of public safety agencies in both Los Angeles and New York. In addition, PSWAC recommended that Public Safety users be granted immediate spectrum relief by permitting increased sharing on unused TV channels nationwide below 512 MHz. *PSWAC Final Report* at p. 22.

[26] *See Errata to the Sixth Further Notice* released on September 12, 1996.

[27] *Sixth Further Notice at* ¶93.

considerations and evaluations in addressing solutions for limiting DTV interference into land mobile stations. Appendix A provides the results of analyses to determine whether the DTV allotments short spaced to land mobile systems can be relocated to the core broadcast television allocation.

As shown in Appendix A, Motorola's list of short-spaced DTV allotments was slightly greater than those identified by the FCC[28]:

FCC Short-Spaced DTV Allotments to Land Mobile

LOCATION	NTSC Channel	DTV Allocation	Affected Land Mobile City
CORONA, CA	52	15	LA (14&16)
SAN FRANCISCO, CA	14	15	SF (16)
PROVIDENCE, RI	10	15	BOS (14&16)
FREDERICK, MD	62	16	DC (17)
KENOSHA, WI	55	16	CHI (15)
MANCHESTER, NH	9	17	BOS (16)
SECAUCUS, NJ	9	18	PHI (19)
SAN FRANCISCO, CA	4	18	SF (17)
VINELAND, NJ	65	21	PHI (20)
WILKES-BARRE, PA	28	13	NY (14)
NEW HAVEN, CT	8	16	NY (15)
LOS ANGELES, CA	13	21	LA (20)
SAN BERNARDINO, CA	18	19	LA (20)
PROVIDENCE, RI	12	13	BOS (14)
WEST PALM BEACH, FL	12	13	MIA (14)

In attempting to relocate these allotments, Motorola again allowed the program to short-space co-channel DTV assignments so that those relative costs could be viewed in contrast to the benefits achieved. Even then, Motorola's best "solution" results in 10 short-spaced DTV-LM allotments to 10 and created 7 DTV to DTV short spaced situations.[29] Thus, it is apparent that additional interference reduction techniques will be needed if the DTV-Land Mobile short-spaced allotments are allowed to remain.

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[28] The discrepancy may be attributable to the low power associated with the DTV allotment.

[29] These results are contained in Appendix A.

In this regard, Motorola urges the FCC to indicate on any short-spaced DTV license that it remains the obligation of the DTV licensee to correct any interference without cost to the land mobile licensee. Essentially replicating the FCC's long standing policy of the "last in fixes the interference problem" the FCC has already imposed this requirement on TV licensees operating on UHF-TV channels 14 and 69 which are immediately adjacent to land mobile allocations.[30] Most notably, the FCC reminds licensees on those channels that they must take special precautions to avoid interference to adjacent channel land mobile licensees and must attenuate their emissions within the land mobile bands to allow reasonable use of the spectrum by land mobile operators.[31] This policy should be reiterated and extended to include DTV assignments on adjacent channels to land mobile allocations over the entire 470-512 MHz band.

In Appendix B, Motorola provides a technical discussion noting that a minimum 30 dB of additional attenuation in the DTV emissions mask is needed to minimize the potential for interference to land mobile from the short-spaced DTV allotments. For some users, even more attenuation will be needed to avoid loss of usable land mobile spectrum. However, even greatly reduced DTV emissions will not eliminate adjacent channel interference problems close to (i.e., within 10 miles) of the DTV transmitters nor does it address the potential for land mobile interference to DTV receivers. This is an issue where continued analyses is needed by all parties concerned -- the land mobile interests, the broadcast industry and the FCC.

V. CONCLUSION.

The FCC has embarked on a historic path that promises to reap great dividends for the American public, the broadcast industry and land mobile users by simply promoting the more efficient use of the greatest untapped spectrum resource available to non-government

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[30] *See* 47 C.F.R. §73.687(e)(3) of the FCC's Rules.

[31] *Id.*

users. Motorola has provided the FCC with recommendations that help with the FCC's plan to recover underutilized portions of the broadcast spectrum for alternative uses. By further reducing DTV assignments in UHF-TV channels 60-69, the FCC will accelerate recovery of this spectrum. While not a panacea given the existence of 97 NTSC stations in this band, Motorola's proposed modification of the FCC's allotment contains significant improvements for land mobile industries without imposing materially higher costs for broadcasters.

Respectfully Submitted,

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Appendix A: Optimizing DTV Allotments for Spectrum Efficiency
Appendix B: TV Interference to Land Mobile

APPENDIX A

Optimizing DTV Allotments for Spectrum Efficiency

Abstract:

Motorola has investigated the FCC channel assignment algorithm and the proposed DTV allotments to each existing NTSC licensed station produced thereby. The algorithm appears to be well designed, and produces results consistent with expectations. The proposed FCC assignments represent one near optimum solution of the perhaps several hundred that exist for this many valued problem. Motorola's analysis attempted to find a more optimal solution to 1) limit DTV allotments within UHF-TV channels 60-69 and 2) reduce instances where DTV allotments are short-spaced to land mobile operations in the 470-512 MHz band.

Introduction

Motorola's analysis of the allotted DTV stations as shown in the Sixth Further Notice of MM Docket No. 87-268, FCC 96-317, has been centered on understanding the simulated annealing code which was used to make these assignments. We used the code to investigate some alternate optimization of the assignments that advance the FCC's stated objectives for both DTV and spectrum recovery. To some degree, limiting allotments in Channels 60-69 now is beneficial to TV licensees because they can be positioned in the band so they will not be required to make multiple channel changes and the new allotments represent negligible changes in the average penalty for each station. This is a measure of how well the code has optimized the overall result.

In this Appendix we will first describe how the code was used, and then show several alternative solutions to that produced by the FCC. The code validation is then described, and several issues are discussed. In the conclusion, recommendations are made regarding the solutions presented herein and the issues that remain unresolved.

Simulated Annealing Code

As discussed in the Sixth Further Notice at paragraph 85, the simulated annealing method "employs a system of penalties that attach to conditions that fall short of specified objectives. The simulated annealing method seeks to minimize the sum of these penalties, also referred to as 'costs,' to achieve an optimum condition." These penalties include DTV-to-NTSC and NTSC-to-DTV cochannel and upper and lower adjacent channel interference penalties, DTV-to-DTV cochannel and upper and lower adjacent channel interference penalties, radio astronomy related adjacent channel penalties for channels 36 and 38, VCR related penalties for channels 3 and 4, FM radio related penalties for channel 6, land mobile channel interference penalties for the relevant channels in the relevant locations, and other penalties designed to promote allocations into the FCC's desired band of channels 7 through 51.

The phrase "an optimum condition" deserves special emphasis. There are approximately 2000 stations in the United States to which this simulated annealing code attempts to assign one of about 40 possible channels. The total number of combinations of channel allotments to stations is, therefore, approximately 40^{2000}, or about 10^{3204}. There is no claim, therefore, that this code finds *the* optimum solution. It only claims to examine the space of possible solutions efficiently and find *an* acceptable solution.

A simple diagram can illustrate this point.

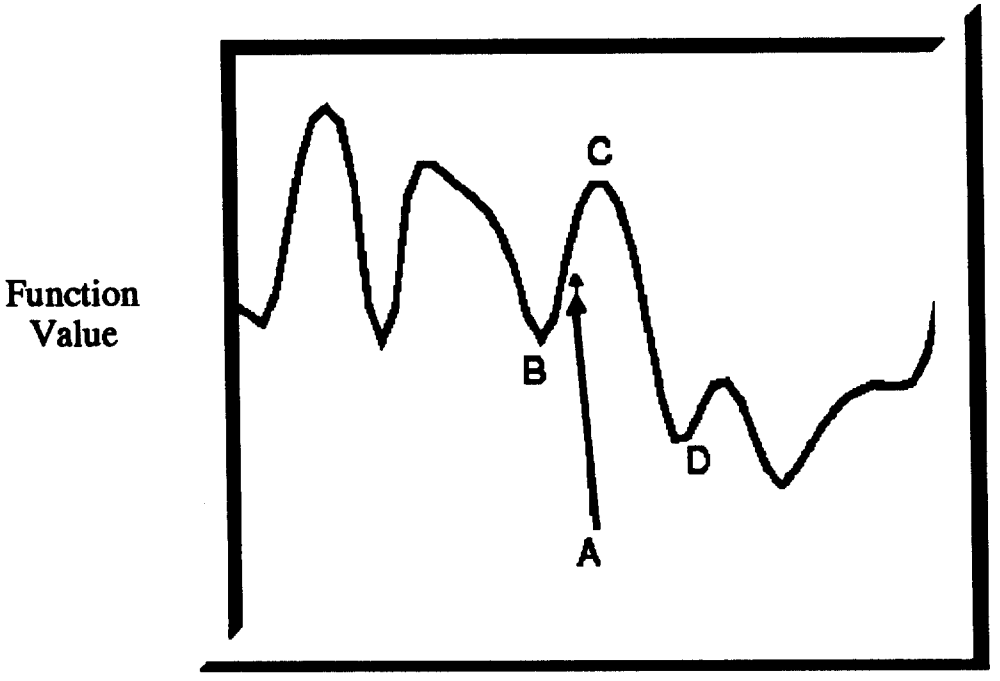

Figure 1

Figure 1 shows an example of a function with many local minima. The goal is to find the set of parameters which yield the lowest value of the function. If our first guess is at position A, a typical maximum descent method of minim searching would find the local minimum at point B. However, it would not be able to go over the local maximum at point C in order to find the local minimum at point D, even though the functional value at D is less than that at B. Simulated annealing, on the other hand, is able to move in the direction of increasing functional value (or increasing penalty in some cases), so it can, in our example, find the local minimum at D. Due to the complexity of the function, however, there is no guarantee that the local minimum which is found is also the absolute minimum. In our picture it is not. Likewise, the solution for station allocations made by the FCC is not an absolute minimum, and it is possible to find other allocations with equivalently low, or even lower, penalties.

Our broad goal has been to find an allocation of DTV channels which is more appropriate from the point of view of land mobile radio operators and, at least, equivalent to the FCC's proposed solution from the point of view of other interested parties. For land mobile operators, a desired solution would have few, if any, allocations in channels 60-69 so that those frequencies could be made available for other uses. Also, the impact on the existing land mobile operation in channels 14-20 should be minimal.

We believe that this approach also holds benefit for the broadcasters. By minimizing the number of allocations in the channel 60-69 band, we minimize the number of modifications that a licensee may require to arrive at the final band configuration that has been proposed by the FCC. By improving the situation in channels 14-20, we also minimize the potential interference from land mobile stations into DTV receivers.

We have approached finding such solutions by changing the penalties applied to various conditions (like allocation into the 60-69 band, or allocations which are adjacent to land mobile allocations) and allowing the program to reallocate the channels. The following sections present the results of these analyses.

Solution 1: Limiting DTV in Channels 60-69

In this first solution, the penalty on an allocation in the 60-69 band was increased, and the program was allowed to reallocate the channels. The penalty was then reset to its original value and, with no station allowed to change its DTV channel, the cost of the resulting solution was found and compared with the solution proposed by the FCC. The results are shown below.

	This Solution	FCC Proposal
Total Cost	202511.3	201479.7
Cost Per Player	106.70	106.15
Number of Assignments in 60-69		
With Unallocated	173	216
Without Unallocated	5	30
Number of Assignments in 14-20		
With Unallocated	293	297
Without Unallocated	293	294
Free Channels (without unallocated)	60,62,63,65,68	68

This solution has a total cost which is greater than that of the FCC's solution by only 0.5%. It has, on the other hand, several advantages to recommend it. Not including the unallocated stations (which we will discuss more later), the FCC's solution makes 30 assignments into the 60-69 band. There is only a single channel (68) which has no assignments anywhere in the continental US. This solution makes only 5 assignments into the 60-69 band, and leaves 5 channels completely free of DTV allocations. Four of those channels (60-65 and 63-68) can be grouped into two pairs which are appropriately spaced for land mobile applications. The remaining 5 allocations in the 60-69 band are shown here.

DTV ASSIGNMENTS REMAINING IN CHANNELS 60-69 (Without Unallocated)			
STATE	*CITY*	*NTSC CHANNEL*	*DTV CHANNEL*
CA	STOCKTON	64	69
NJ	CAMDEN	23	66
NJ	NEWTON	63	61
PA	ALLENTOWN	69	67
PA	PHILADELPHIA	17	64

Attached as Annex 1 to this Appendix is a comparison of this solution and the proposed allotments contained in the FCC's Sixth Further Notice showing only those allotments that are modified.

Solution 2: Minimizing Impact to Land Mobile at 470-512 MHz.

In this next solution, we investigate assignments in the previous solution which might cause interference to the existing land mobile radio operators in the channel 14-20 band. According to the Sixth Further Notice, the desired minimum spacing between these systems and new DTV assignments is 155 miles for co-channel and 110 miles for adjacent channel situations. However, in the FCC's proposed solution, footnote 96 (as corrected in the Erratum) states:

> The DTV allotment on channel 16 in New Haven, CT, would be only 117 miles from the geographic reference point for co-channel land mobile operations on channel 16 in Boston, MA. The twelve cases where DTV allotments would be less than 110 miles from adjacent channel land mobile operations are:
>
> Channel 15, Corona, CA (land mobile channels 14 and 16 in Los Angeles, CA)
> Channel 15, San Francisco, CA (land mobile channel 16 in San Francisco, CA)
> Channel 15, Providence, RI (land mobile channel 14 and 16 in Boston, MA)
> Channel 16, New Haven, CT (land mobile channel 15 in New York, NY)
> Channel 16, Frederick, MD (land mobile channel 17 in Washington, DC)
> Channel 16, Kenosha, WI (land mobile channel 15 in Chicago, IL)
> Channel 17, Manchester, NH (land mobile channel 16 in Boston, MA)
> Channel 18, San Francisco, CA (land mobile channel 17 in San Francisco, CA)
> Channel 18, Secaucus, NJ (land mobile channel 19 in Philadelphia, PA)
> Channel 19, San Bernardino, CA (land mobile channel 20 in Los Angeles, CA)
> Channel 21, Los Angeles, CA (land mobile channel 20 in Los Angeles, CA)
> Channel 21, Vineland, NJ (land mobile channel 20 in Philadelphia, PA)

Our analysis confirms the FCC's list as it relates to their proposed allotment plan.

The same analysis on Motorola's Solution 1 shown above yields:

LOCATION	NTSC Channel	DTV Allocation	Interfered LM	Separation (km)
Ca Los Angeles	13	15	LA (14&16)	25 km
Ca San Mateo	60	15	SF (16)	10 km
Ma Marlborough	66	15	BOS (14&16)	36 km
Oh Youngstown	27	15	PITT (14)	88 km
Md Frederick	62	16	DC (17)	52 km
Wi Kenosha	55	16	CHI (15)	76 km
Ct New Haven	8	16	NY (15)	111 km
Nh Manchester	9	17	BOS (16)	82 km
Nj Secaucus	9	18	PHI (19)	129 km
Ca San Francisco	9	18	SF (17)	4 km
Ca San Bernardino	18	19	LA (20)	52 km
Nj Vineland	65	21	PHI (20)	37 km
Ca Los Angeles	22	21	LA (20)	25 km

As can be seen, the list of problem assignments is very much the same as the FCC's (except for Youngstown, OH). Only the stations to which the DTV channels have been assigned has changed, slightly.

In addressing this problem, Motorola examined each one of these allocations on a case-by-case basis to determine all of the channels which were available to be assigned to each station for DTV purposes. In attempting to move these problem assignments to different channels, we often found that the cost function was so high that the program labeled the solution as "invalid". Under further investigation, we discovered that the reason for this was a hard limit on the station to station distance allowed for cochannel DTV assignments. This limit, we found, was set at 175 km. So, even if an assignment were made with a distance between cochannel DTV assignments of 174 km, the program would label the solution as "invalid". However, a shorter spacing often might be reasonable (based on terrain, coverage areas, etc.) and so we reallocated certain of these stations in violation of this 175 km hard limit.

In order to compare costs, therefore, some changes had to be made to the program. Rather than use a minimum range of 175 km, we used a minimum range of 100 km and allowed the penalties to increase from 175 km to 100 km employing the same penalty function used from 320 km to 175 km. (Care was taken not to change the function itself. Only the cutoff point was changed.) The results of this process are shown below.

	This Solution	FCC's Proposals
Total Cost	212894.8	201479.7
Cost Per Player	112.17	106.15
Number of Assignments in 60-69		
With Unallocated	173	216
Without Unallocated	5	30
Number of Assignments in 14-20		
With Unallocated	288	297
Without Unallocated	288	294
Free Channels (without unallocated)	60,62,63,65,68	68

As can be seen, the cost for this solution is greater than the cost of the proposed FCC solution by about 5.7%. However, there are distinct advantages to such a solution. The potential problems caused by DTV allocations adjacent to land mobile have been dramatically reduced. The remaining problems are:

LOCATION	NTSC Channel	DTV Allocation	Interfered LM	Separation (km)
Ca San Mateo	60	15	SF [16]	10 km
Oh Youngstown	27	15	PITT (14)	88 km
Md Frederick	62	16	DC (17)	52 km
Wi Kenosha	55	16	CHI (15)	76 km
Ct New Haven	8	16	NY (15)	111 km
Nj Secaucus	9	18	PHI (19)	129 km
Ca Los Angeles	22	21	LA (20)	25 km

This improvement has been gained at a cost (demonstrated by the increased total cost of the solution) of "short-spacing" several DTV channel assignments. Those assignments are shown in the list below, in which N# refers to the NTSC channel allocation of the station, and D# refers to the DTV allocation.

List of Short-Spaced DTV Assignments

1. Sacramento, CA [N31,D21] and San Francisco, CA [N9, D21] spaced 102 km.
2. Manchester, NH [N9,D29] and Rutland, VT [N28,D29] spaced 144 km.
3. Hartford, CT [N18,D35] and Marlborough, MA[N66,D35] spaced 128 km.
4. Hartford, VT [N31,D35] and Marlborough, MA[N66,D35] spaced 142 km.
5. San Bernardino, CA [N18,D39] and Twenty-nine Palms CA [N31,D39] spaced 138 km.
6. Bakersfield, CA [N39,D51] and Los Angeles, CA [N13,D51] spaced 148 km.
7. Montclair, NJ [N50, D56] and Vineland, NJ [N65,D56] spaced 137 km.

Solution 3: Further Optimization of Channels 60-69

In this last solution, we take solution 2 one step further. We have already eliminated the most problematic DTV assignments adjacent to land mobile allocations. Now we attempt to eliminate even more of the assignments in the 60-69 band by the same technique of short-spacing some cochannel DTV allocations. Again, as in solution 2, we have had to decrease the minimum spacing requirement for cochannel DTV allocations to 100 km in order to calculate the cost function. The results are summarized here.

	This Assignment	FCC Assignment
Total Cost	212946.1	201479.7
Cost Per Player	112.19	106.15
Number of Assignments in 60-69		
With Unallocated	170	216
Without Unallocated	2	30
Number of Assignments in 14-20		
With Unallocated	288	297
Without Unallocated	288	294
Free Channels (without unallocated)	60,62,63,64,65,66, 67,68	68

Again, the cost function is greater than that for the FCC's solution by 5.7%. However, the advantages for this solution are many. The main problems with DTV assignments adjacent channel to land mobile are still resolved, and this time the number of allocations in the 60-69 band has been reduced to only two. They are:

DTV ASSIGNMENTS REMAINING IN CHANNELS 60-69 (Without Unallocated)			
STATE	**CITY**	**NTSC CHANNEL**	**DTV CHANNEL**
CA	STOCKTON	64	69
NJ	NEWTON	63	61

These benefits have been gained at the cost of short-spacing the following set of channels.

List of Short-Spaced Assignments

1. Sacramento, CA [N31,D21] and San Francisco, CA [N9, D21] spaced 102 km.
2. Manchester, NH [N9,D29] and Rutland, VT [N28,D29] spaced 144 km.
3. New York, NY [N4,D34] and Philadelphia, PA [N17,D34] spaced 128 km.
4. Harrisburg, PA [N33,D34] and Philadelphia, PA [N17,D34] spaced 143 km.
5. Hartford, CT [N18,D35] and Marlborough, MA[N66,D35] spaced 128 km.
6. Hartford, VT [N31,D35] and Marlborough, MA[N66,D35] spaced 142 km.
7. San Bernardino, CA [N18,D39] and Twenty-nine Palms CA [N31,D39] spaced 138 km.
8. Baltimore, MD [N45,D40] and Allentown, PA [N69,D40] spaced 171 km.
9. New York, NY [N25,D40] and Allentown, PA [N69,D40] spaced 125 km.
10. Camden, NJ [N23,D44] and Newark, NJ [N68, D44] spaced 135 km.
11. Bakersfield, CA [N39,D51] and Los Angeles, CA [N13,D51] spaced 148 km.
12. Montclair, NJ [N50, D56] and Vineland, NJ [N65,D56] spaced 137 km.

Conclusion

Our work using the FCC's simulated annealing code has given us great confidence that the code is doing properly what it was designed to do. Based on various penalty factors, the code is assigning DTV channels in a configuration which finds a minimum solution. We have verified that when penalties are increased for certain channels, the code will tend not to allocate those channels to stations. We also have seen that attempting to manually change the allocations which have been made by the code without increasing the penalty function is extremely difficult. Manually changing the allocations and even getting a valid solution is quite difficult. Different optimal solutions, of course, can be obtained depending on the penaly factors assigned to various conditions.

We have demonstrated that, within the guidelines established by the FCC, an allocation exists which is equivalent in "cost" to that of the FCC, but which has fewer allocations in channels 60-69 (by a factor of six.) With some further adjustment of the FCC's assignment policies, even more efficient solutions can be obtained.